Post-nesting movements of a loggerhead sea turtle

Report Submitted to:

The U.S. Fish and Wildlife Service
Gloucester, VA

and

The U.S. Army Corps of Engineers
Norfolk, VA

by

John A. Keinath
Debra E. Barnard
John A. Musick

February, 1994

Virginia Institute of Marine Science
School of Marine Science
The College of William and Mary
Gloucester Point, Virginia 23062

INTRODUCTION

Up to 10,000 juvenile loggerheads inhabit Chesapeake Bay each summer (Byles, 1988; Keinath et al., 1987; Keinath and Musick, 1991; Lutcavage, 1981; Lutcavage and Musick, 1985; Musick, 1988; Musick et al., 1985), but nesting female loggerheads are rare north of Cape Hatteras, with typically two or three nests occurring annually in Virginia (Byles and Musick, 1981; Jones and Musick, 1989; Musick et al., 1985). In 1989 eight nests were reported, and seven of those were found between Corolla, North Carolina and Sandbridge, Virginia. One female was flipper-tagged after her first nesting, and was observed again 28 days later. By dimensions of the turtle crawls and internesting interval we presumed the same turtle deposited a total of five nests in Virginia. Two other nests were found, and by the similar dimensions of the two crawls (which were different from the tagged turtle) and internesting interval we assume a single turtle laid those two nests. Internesting interval is important because a single loggerhead usually nests several times each summer with about 14 days between each nesting.

Flipper-tagging has traditionally been the most common method used to study movements of free ranging sea turtles, but these programs suffer from loss of tags, and only reveal point to point movement. Despite drawbacks, flipper-tagging has revealed the greatest amount of information on movements and philopatry of free ranging sea turtles. Other methods have been employed to track sea turtles: Balloons (Carr, 1963; 1972), floats (Carr et al., 1974, Meylan, 1982, Mortimer, 1981, Mortimer and Portier, 1989), and dye (Witham et al., 1973) were used to track movements of sea turtles off the nesting beaches, but these experiments were of limited duration and had adverse drawbacks (Carr, 1963). Carr (1963) suggested electronic tracking would be ideal to monitor sea turtles in their natural environment.

Radio, sonic, and satellite telemetry has recently been used successfully to monitor wild sea turtle movements. In addition, behavioral data can also be gathered with modern transmitters. Both radio and sonic telemetry require expensive vessel support to stay in contact with the transmitters. This limits duration of tracks from days up to a few weeks (Keinath, 1986, 1991). Satellite telemetry demands a large initial investment, but provides months of data. The Marine Turtle Project at the Virginia Institute of Marine Science (VIMS) has developed relatively inexpensive satellite transmitters, and VIMS has monitored over 20 sea turtles of three species with satellite telemetry since 1985 (Keinath et al., 1992; Keinath, 1993).

Satellite telemetry utilizes radio transmitters which relay signals to satellites which in turn relay data to earth stations (Byles and Keinath, 1990; Keinath, 1991, 1993). Movements of Kemp's ridley, Lepidochelys kempii (Byles, 1989; Keinath, 1993), leatherback, Dermochelys coriacea (Duron-Dufrenne, 1987; Keinath and Musick, 1993), and loggerhead sea turtles, Caretta caretta (Byles, 1988; Byles and Dodd, 1989; Keinath et al., 1989; Stoneburner, 1982; Timko and Kolz, 1982) have been successfully studied via satellite.

Satellite telemetry systems allow collection of data which have included water temperature and precise diving/surfacing parameters. Diving behavior data from satellite transmitters have been reported for Kemp's ridley (Byles, 1989; Keinath, 1993) and loggerhead sea turtles

(Byles and Dodd, 1989; Keinath et al., 1989; Keinath, 1993), and the VIMS research team was the first to successfully study leatherback diving behavior via satellite (Keinath and Musick, 1993). The present report provides a description of movements of a female loggerhead turtle which was tagged with a satellite transmitter while nesting at Back Bay National Wildlife Refuge.

MATERIALS AND METHODS

Satellite telemetry uses UHF transmitters which transmit signals to a satellite which in turn relays them to an earth station. The Argos satellite telemetry system utilizes NOAA Tiros satellites to calculate transmitter location by doppler shift of the transmitter's radio frequency (Kenward, 1987), and also allows transmission of digital data collected by transmitter sensors. Data collected by on board sensors used in this study included water temperature and diving data: mean dive duration in a 12 h period and number of dives in that 12 h period (Byles, 1989; Byles and Dodd, 1989; Keinath, 1991, 1993; Keinath et al. 1989). A salt water switch was used to determine these dive parameters, and the switch also served to turn off the transmitter while underwater (UHF radio waves do not travel through seawater) to extend the battery life from 25 - 30 days to up to a year of operation. Because waves breaking over the sea water switch would give erroneous dive data, submersions under one minute were disregarded. Data was transmitted from satellites to ground stations, and processed and disseminated by Argos (Byles and Keinath, 1990). Data was accessed via computer and modem, and back up diskettes or print-outs of monthly data were available from Argos. Location, parameters sent by the transmitter, day and time of reception, and probability of location accuracy were among data received. From this dive data the duration of time spent submerged and percentage of time spent submerged in each 12 h segment was calculated.

In contrast to radio and sonic telemetry which can provide continuous data, the Argos system provides only a limited number of daily fixes, depending on latitude (Kenward, 1987). Since Tiros satellites are polar orbiting, more fixes are possible at higher latitudes (up to 15 per day) than at the equator (up to seven per day), and since the transmitter is below the surface most of the time, probability of receiving a location is decreased further. Up to two fixes per day were received from wild loggerhead turtles tracked off the east coast of the US, although there were occasions when no positions were recorded for days (Keinath, 1993).

Nesting females were monitored on the beach between Sandbridge and the North Carolina state line by personnel from the Back Bay National Wildlife Refuge (BBNWR). On 11 July 1993 an emerging female was allowed to complete nesting, was constrained to prevent escape, then weighed and measured (Photograph 1). A satellite transmitter (Telonics model ST-6) was affixed to the carapace of the turtle with plastic resin, a non-invasive procedure (Photographs 2 and 3). We have utilized this method successfully on over 15 turtles (Keinath, 1993). The turtle was then released at BBNWR that morning (Photograph 4), and movements and behavior were monitored until the transmitter failed on 28 July 1993. Travel routes were plotted and distances traveled and movement speeds were calculated. Diving behavior was described from data collected by sensors on board the transmitters.

RESULTS

Between the release date (11 July 1993) and the date of last transmission (28 July 1993) the turtle traveled within Virginia's waters (Table 1, Figure 1). From 11 July to 18 July the turtle remained off southern Virginia. On 19 July the turtle started to travel north north-east, and on 20 July the turtle was off the eastern shore and started to travel shoreward. By 21 July the turtle was within Chesapeake Bay, where it remained until 24 July. The animal then travelled south along the Virginia Beach coast, and remained off Back Bay National Wildlife Refuge and False Cape State Park until 27 July, when it again began to travel north east. The last transmission was on 28 July, when the turtle was off the southern end of the Eastern Shore of Virginia (Table 1, Figure 1). The turtle moved at speeds up to 4 km/h, with a mean speed of 1.49 km/h (Table 1).

The turtle spent an average of 5.45 minutes submerged per dive in a 12 h period, up to a maximum average of 11 minutes per dive in a 12 h period (Table 2). The turtle dove up to 237 times per 12 h, with an average of 125.97 dives in a 12 h period (Table 2). During these 12 h periods, the turtle spent an average of 86.66 percent of the time submerged, with a maximum of 97.32 percent (Table 2).

DISCUSSION

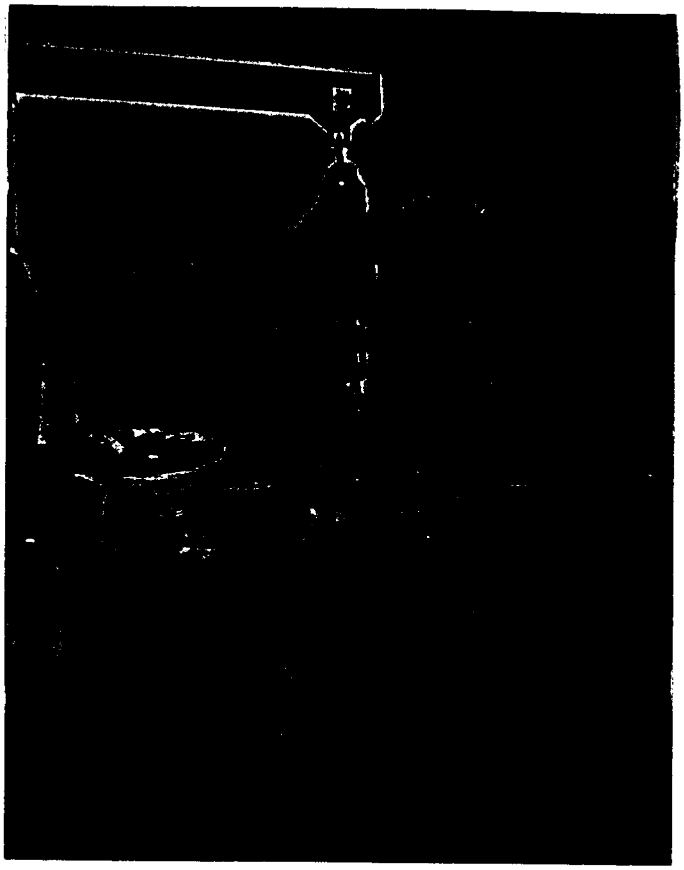
This nesting female loggerhead exhibited movements very different than a nesting female tracked in 1992 (Musick et al., 1993; Keinath, 1993; Keinath et al., 1994). That turtle, like some juvenile loggerheads and ridleys we have tracked in the past traveled nearshore, south around Cape Hatteras (Keinath, 1993). However, the present turtle's track was of very short duration (17 days), and comparisons would be meaningless since the track of this turtle did not extend into the cooler months. This turtle inhabited Virginia's nearshore habitats and traveled to over 30 km offshore. Interestingly, dive data suggest that the turtle did not nest within the 17 day track, but the turtle entered lower Chesapeake Bay where few adults are found. The behavior of this adult female was very different than that of juvenile loggerheads studied in Virginia. Juveniles tended to become resident during summer in channels and had relatively limited home ranges (Byles, 1988). Although conclusions based on two turtles should be interpreted parsimoniously, movements exhibited by this turtle and the nesting female tracked in 1992 (Keinath et al., 1994) suggest that females may utilize the area around Chesapeake Bay mouth strictly as a feeding area during the short nesting period, but spend the majority of their time foraging to the south.

This turtle exhibited travel speeds comparable to juvenile sea turtles previously studied by satellite telemetry (Keinath, 1993), and diving behavior intermediate between actively migrating turtles in the ocean and sedentary turtles in Chesapeake Bay (Byles, 1988; Keinath, 1993). These diving patterns reflect the active but relatively local movements made by this turtle.

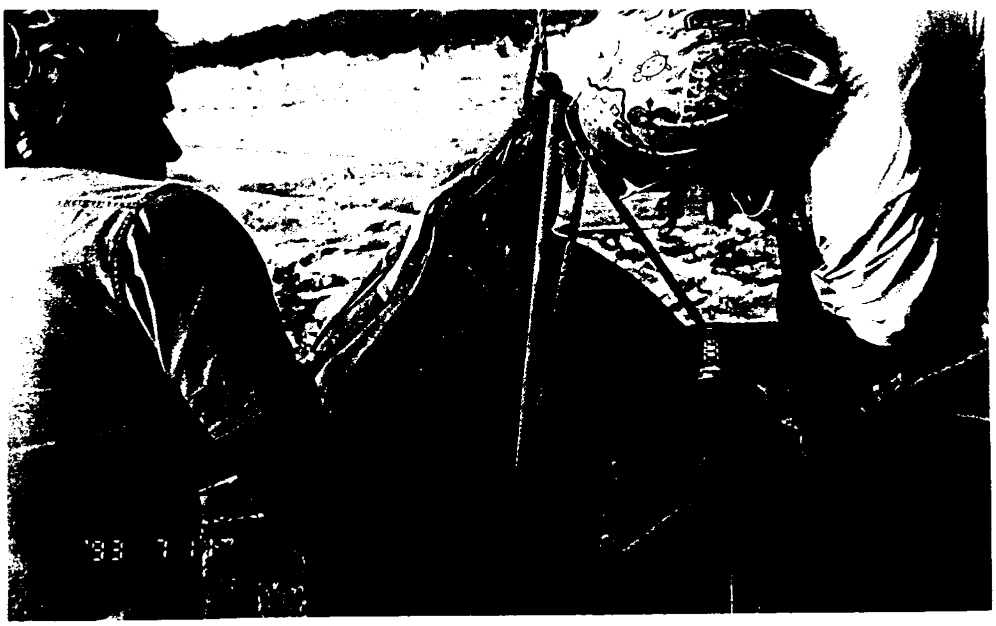
Although we expected to attain up to 9 months of data, transmissions stopped after 17 days. Cessation of signals may be due to several factors: death of the turtle, detachment of the transmitter from the turtle (the transmitters are negatively buoyant and would sink), or failure of the transmitter due to sea water intrusion or electronic problems. Death of the turtle cannot be determined, but we have used the same attachment technique on 16 other sea turtles and have gathered data over 150 days on six of those turtles, and have had reports of sighting of turtles with transmitters attached after transmission ceased, thus we feel the transmitter did not detach from the turtle. From 1989 - 1992 we have utilized backpack versions of the larger model of satellite transmitter (ST-3) on seven sea turtles and received data from 50 to 271 days. We used the present transmitters (ST-6) on eight turtles and received data from 18 to 83 days, with only two transmitting over 45 days. We feel there is a problem with the ST-6 transmitters, and suggest using the ST-3 version when size of the turtle is not a limiting factor.

CONCLUSIONS

Although conclusions based on a meager sample should be interpreted with caution, it appears female loggerheads nesting in Virginia utilize the areas off shore of Chesapeake Bay mouth and within the lower Chesapeake Bay for feeding during the nesting season. These adult turtles do not behave as juvenile which inhabit deeper channels within the bay and move passively with tides. Adult loggerheads, like juveniles, must travel south in the colder months, and like juveniles may travel as far as Florida to overwinter. More females nesting in Virginia need to be studied.



Photograph 1. Constraint and weighing of nesting loggerhead sea turtle.



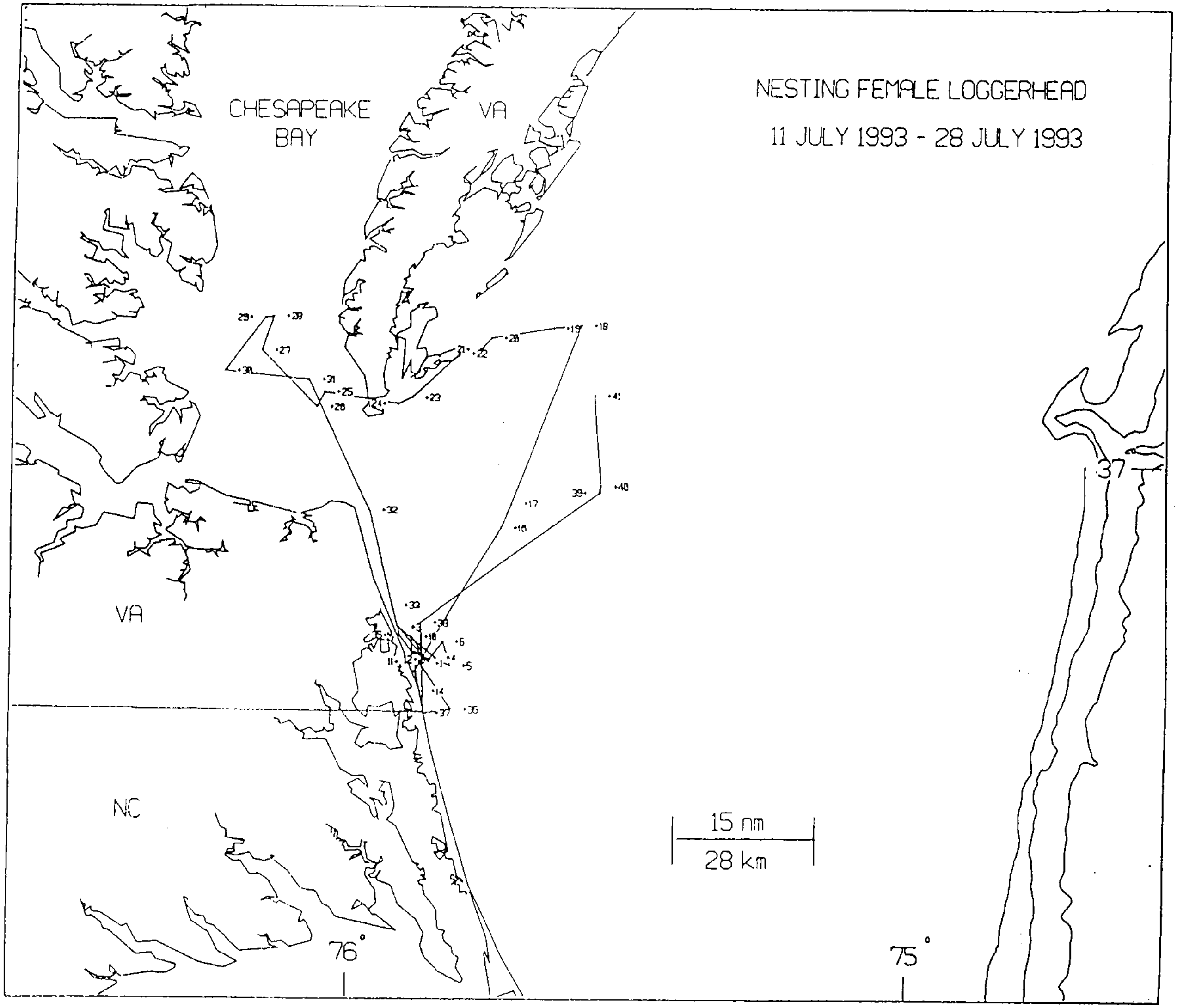
Photograph 2. Preparation of turtle's carapace for transmitter mounting.

Photograph 3. Mounted satellite transmitter.

Photograph 4. Loggerhead turtle with satellite transmitter returning to the sea.

Figure 1. Positions of a satellite tracked loggerhead turtle found nesting on Back Bay National Wildlife Refuge on 11 July 1992. Each numbered point corresponds to "NUMBER" in Table 1.

1229



NESTING FEMALE LOGGERHEAD
11 JULY 1993 - 28 JULY 1993
CHESAPEAKE
BAY
VA
VA
NC
15 nm
28 km
76°
75°
37

Table 1. Data from nesting loggerhead tracked via satellite in 1993. POINT NO. corresponds to number points in Figure 1. TIME in Greenwich mean time, LAT = north latitude, LONG = west longitude, TSLL = time since last location in minutes, DSLL = distance since last location in km, SPEED = speed since last location in km/h.

POINT NO.	DATE	TIME (GMT)	LAT	LONG	TSLL (m)	DSLL (km)	SPEED (km/h)
1	7/12/93	8: 6:33	36.634	75.868			
2	7/12/93	9:45:58	36.640	75.864	99.42	0.76	0.46
3	7/12/93	22: 9:38	36.698	75.912	743.67	7.74	0.62
4	7/13/93	7:54: 8	36.644	75.848	584.50	8.28	0.85
5	7/14/93	11:50:34	36.630	75.820	1676.43	2.94	0.11
6	7/14/93	13:32:18	36.672	75.833	101.73	4.81	2.84
7	7/15/93	11:25:39	36.642	75.857	1313.35	3.96	0.18
8	7/15/93	22:47: 1	36.655	75.885	681.37	2.89	0.25
9	7/16/93	0:27: 7	36.637	75.859	100.10	3.06	1.84
10	7/17/93	20:10:49	36.681	75.889	2623.70	5.58	0.13
11	7/17/93	22: 3:56	36.637	75.890	113.12	4.89	2.60
12	7/18/93	8:35: 6	36.641	75.857	631.17	2.98	0.28
13	7/18/93	12: 0:59	36.652	75.887	205.88	2.94	0.86
14	7/18/93	19:56:51	36.586	75.875	475.87	7.42	0.94
15	7/18/93	21:38:12	36.620	75.884	101.35	3.86	2.29
16	7/19/93	23: 3:15	36.883	75.729	1525.05	32.34	1.27
17	7/20/93	0:38:14	36.930	75.710	94.98	5.49	3.47
18	7/20/93	11:18:50	37.252	75.588	640.60	37.40	3.50
19	7/20/93	14:39:29	37.247	75.638	200.65	4.46	1.33
20	7/20/93	19:34:48	37.229	75.749	295.32	10.03	2.04
21	7/20/93	21:13:21	37.208	75.767	98.55	2.83	1.72
22	7/21/93	7:57:15	37.200	75.807	643.90	3.65	0.34
23	7/21/93	12:38:11	37.120	75.892	280.93	11.66	2.49
24	7/21/93	14:16:27	37.109	75.916	98.27	2.45	1.50
25	7/21/93	19:22:40	37.129	76.050	306.22	12.09	2.37
26	7/21/93	23:58:20	37.102	76.062	275.67	3.18	0.69
27	7/22/93	13:54:46	37.204	76.162	836.43	14.39	1.03
28	7/22/93	20:48:58	37.267	76.142	414.20	7.22	1.05
29	7/23/93	10:52: 6	37.264	76.157	843.13	1.37	0.10
30	7/23/93	22:15:33	37.167	76.228	683.45	12.48	1.10
31	7/24/93	10:40:45	37.152	76.077	745.20	13.49	1.09
32	7/24/93	22:51:44	36.916	75.967	730.98	28.00	2.30
33	7/25/93	8:48: 7	36.738	75.925	596.38	20.14	2.03
34	7/25/93	10:30: 0	36.705	75.916	101.88	3.76	2.21
35	7/25/93	11:11:16	36.684	75.911	41.27	2.38	3.46
36	7/25/93	20:10:55	36.554	75.817	539.65	16.71	1.86
37	7/25/93	22:31:30	36.548	75.868	140.58	4.60	1.97
38	7/27/93	10: 4:23	36.706	75.873	2132.88	17.57	0.49
39	7/27/93	23:27:54	36.950	75.553	803.52	39.34	2.94
40	7/28/93	1:10:33	36.962	75.551	102.65	1.35	0.79
41	7/28/93	9:51:16	37.125	75.563	520.72	18.15	2.09
						Mean	1.49

Table 2. Temperature and diving data collected from nesting loggerhead tracked via satellite in 1993. TIME in Greenwich mean time, TEMP = transmitter temperature in C, MEAN DIVE = mean dive duration in each 12 hour period, in minutes, NO. DIVE = number of dives in each 12 hour period.

DATE	TIME (GMT)	TEMP (C)	MEAN DIVE	NO. DIVE
12-Jul-1993	11:30:28	25.90	6.70	53
13-Jul-1993	1:34:37	25.90	7.07	93
13-Jul-1993	12: 5:35	25.90	7.00	91
13-Jul-1993	22:37:26	27.53	7.37	92
14-Jul-1993	11: 4:10	26.55	7.97	84
14-Jul-1993	23: 2:26	24.26	11.10	57
15-Jul-1993	10:48:42	14.10	2.97	106
15-Jul-1993	22:43: 4	25.90	4.23	145
16-Jul-1993	12:40:48	25.90	6.83	99
17-Jul-1993	1:48:40	25.90	3.90	179
17-Jul-1993	18:32:48	25.90	4.67	140
17-Jul-1993	23:36:26	25.90	4.47	148
18-Jul-1993	12: 1:40	25.90	5.47	121
18-Jul-1993	23:20: 4	25.90	4.17	159
19-Jul-1993	13:14:45	16.07	5.20	131
19-Jul-1993	23: 3: 2	23.93	5.53	117
20-Jul-1993	11:17:37	18.69	4.57	129
21-Jul-1993	0:17:17	23.60	3.00	208
21-Jul-1993	11:21: 2	24.26	4.90	143
21-Jul-1993	23:54:11	25.24	4.23	157
22-Jul-1993	13:53:25	25.90	8.00	83
23-Jul-1993	9:15:29	25.24	7.07	96
23-Jul-1993	10:48:52	24.91	6.50	59
24-Jul-1993	10:37:58	24.59	4.97	93
24-Jul-1993	22:48:24	21.31	3.70	180
25-Jul-1993	10:27:35	22.62	2.83	237
25-Jul-1993	22:29:41	22.29	3.33	192
26-Jul-1993	12:27:30	24.26	4.50	114
26-Jul-1993	23:51:12	22.95	5.77	117
27-Jul-1993	13:48:10	25.24	7.30	86
27-Jul-1993	23:31: 1	24.59	5.00	123
		Mean	5.45	126
		N	30	30

LITERATURE CITED

Byles, R.A. 1988. The behavior and ecology of sea turtles in Virginia. Unpublished PhD Dissertation. Virginia Inst. Mar. Sci., College of William and Mary, Gloucester Point, Va, 112 pp.

Byles, R.A. 1989. Satellite telemetry of Kemp's ridley sea turtles, lepidochelys kempi, in the Gulf of Mexico, p. 25-26. In: Eckert, Eckert, and Richardson (Compilers), Proc. 9th Ann. Workshop in Sea Turtle Conserv. and Biol. NOAA Tech. Mem. NMFS-SEFC-232.

Byles, R.A. and C.K. Dodd. 1989. Satellite biotelemetry of a loggerhead sea turtle (Caretta caretta) from the east coast of Florida, p. 215-217. In: Eckert, Eckert, and Richardson (Compilers), Proc. 9th Ann. Workshop in Sea Turtle Conserv. and Biol. NOAA Tech. Mem. NMFS-SEFC-232.

Byles, R.A. and J.A. Keinath. 1990. Satellite monitoring sea turtles, pp. 73-75. In: Richardson, Richardson, and Donnelly (compilers), Proceedings of the Tenth Annual Workshop on Sea Turtle Conservation and Biology. NOAA Tech. Memo. NMFS-SEFC-278.

Byles, R.A. and J.A. Musick. 1981. Nesting of loggerhead sea turtles, Caretta caretta, in Virginia. Final rep. submitted to the E.P.A. 30 pp.

Carr, A. 1963. Orientation problems in the high seas travel and terrestrial movements of marine turtles. In: Slater (ed.), Biotelemetry: The use of Telemetry in Animal Behavior and Physiology in Relation to Ecological Problems. Macmillan Co., New York, NY. 179-193.

Carr, A. 1972. The case for long-range chemoreceptive piloting in Chelonia. In: Galler, Schmidt-Koenig, Jacobs, and Belleville (eds.), Animal Orientation and Navigation. Nat. Aeronaut. Space Admin., Wash. D.C., SP-262. 469-483.

Carr, A., P. Ross, and S. Carr. 1974. Internesting behavior of the green turtle, Chelonia mydas, at a mid-oceanic island breeding ground. Copeia 1974(3):703-706.

Duron-Dufrenne, M. 1987. Premier suivi par satellite en Atlantique d'une tortue luth Dermochelys coriacea. C.R. Aca. Sc. Paris. t. 304, Serie III, n 15:399-402.

Jones, B. and J.A. Musick. 1989. Loggerhead hatchling success rates in Virginia, 1985-1987. In: Eckert, Eckert, and Richardson (compilers), Proc. Ninth Ann. Workshop on Sea Turtle Conserv. and Biol. 243-245.

Keinath, J.A. 1986. A telemetric study of the surface and submersion activities of Dermochelys coriacea and Caretta caretta. MS Thesis, Univ. R.I. 85 pp.

Keinath, J.A. 1991. State of the art sea turtle tracking, p. 215-220. In: Geo-Marine (Compiler), Proc. 11th Ann. Gulf of Mexico Information Transfer

Meeting. US Dept. Int., Miner. Manag. Serv., New Orleans, LA. OCS Study MMS 91-0040.

Keinath, J.A. 1993. Movements and behavior of wild and head-started sea turtles. Ph.D. Dissertation. Virginia Inst. Mar. Sci., College of William and Mary, Gloucester Point, Va, 206 pp.

Keinath, J.A. and J.A. Musick. 1991. Loggerhead sea turtle, p. 445-448. In: K. Terwilliger (coord.). Virginia's Endangered Species. McDonald and Woodward Pub. Co. Blacksburg, VA.

Keinath, J.A. and J.A. Musick. 1993. Internesting movements and behavior of a leatherback turtle, Dermochelys coriacea. Copeia 4:1010-1017.

Keinath, J.A., R.A. Byles, and J.A. Musick. 1989. Satellite telemetry of loggerhead turtles in the western north Atlantic, 75-76. In: Eckert, Eckert, and Richardson (Compilers), Proc. 9th Ann. Workshop on Sea Turtle Conserv. and Biol. NOAA Tech. Mem. NMFS-SEFC-232.

Keinath, J.A., J.A. Musick, and D.E. Barnard. 1992. Sea turtles off the North Carolina coast, p. 111-117. In: Proc. 4th Atlantic Outer Continental Shelf Region Information Transfer Meeting, Sept., 1991. OCS Study MMS 92-0001.

Keinath, J.A., J.A. Musick, and D.E. Barnard. 1994. Movements of head-started and nesting loggerhead sea turtles. Final Report to Back Bay National Wildlife Refuge, US Fish and Wildlife Service. 79 pp.

Keinath, J.A., J.A. Musick, and R.A. Byles. 1987. Aspects of the biology of Virginia's sea turtles: 1979-1986. Virginia J. Sci. 38(4):329-336.

Kenward, R.E. 1987. Wildlife Radio Tagging. Academic Press, London. 222 pp.

Lutcavage, M. 1981. The status of Marine turtles in Chesapeake Bay and Virginia coastal waters. Unpublished Masters thesis. Virginia Inst. Mar. Sci., College of William and Mary, Gloucester Point, Va., 126 pp.

Lutcavage, M. and J.A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. Copeia 1985:449-456.

Meylan, A. 1982. Behavioral ecology of the West Caribbean green turtle (Chelonia mydas) in the internesting habitat. In: Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Inst. Press, Washington, D.C. 67-80.

Mortimer, J.A. 1981. Reproductive ecology of the green turtle, Chelonia mydas, at Ascension Island. Ph.D. Diss., Univ. Fla., Gainesville. 162 pp.

Mortimer, J.A. and K.M. Portier. 1989. Reproductive homing and internesting behavior of the green turtle (Chelonia mydas) at Ascension Island, South Atlantic Ocean. Copeia 1989(4):962-977.

Musick, J.A. 1988. The sea turtles of Virginia, second revised edition. Virginia Sea Grant Program, Virginia Inst. Mar. Sci., Gloucester Point, Va. 20 pp.

Musick, J.A., R. Byles, R. Klinger, and S. Bellmund. 1985. Mortality and behavior of sea turtle in the Chesapeake Bay. SumMary Report for 1979 - 1983. Submitted to the National Marine Fisheries Service. VIMS, College of William and Mary. Gloucester Pt., VA. 52 pp. and 2 app.

Stoneburner, D.L. 1982. Satellite telemetry of loggerhead sea turtle movement in the Georgia Bight. Copeia 1982(2):400-408.

Timko, R.E. and A.L. Kolz. 1982. Satellite sea turtle tracking. Mar. Fish. Rev. 44(4):19-24.

Witham, R., R.M. Gallagher, and M.L. Hollinger. 1973. Tracking green turtles with fluorescent dye. Prog. Fish Cult. 35(4):239-240.